



## Case report

## A fatal case of commotio cordis caused by an accidental fall on the beach



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## ABSTRACT

Sudden cardiac death is a major health problem and a recurring issue in forensic medicine. Most cases are attributed to congenital heart disease, cardiomyopathy, myocarditis, pathology of the coronary arteries, long or short QT interval syndromes, Brugada syndrome or secondary toxic effects of cardioactive drugs. Sudden death caused by Commotio cordis after an accidental fall is very rare in women. Victims are essentially young people who die following a direct blow to the chest sustained during physical activity.

In the following, we report a case of an adult with no significant past medical history, walking on the beach with friends, who died from commotio cordis following an accidental fall on the wet sand. This article deals with post-mortem diagnosis, and demonstrates the importance of a detailed understanding of the circumstances surrounding the death, as well as systematic histological examination of the heart, as the heart will generally appear normal under macroscopic examination. It is important to note that commotio cordis can also occur in adults.

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## 1. Introduction

Sudden cardiac death (SCD) constitutes a major health problem, and is one of the topics which appears most frequently in the forensic literature.<sup>1</sup> SCD in young people may be a consequence of congenital heart disease, cardiomyopathy, myocarditis, pathology of the coronary arteries, long or short – QT interval syndromes, Brugada syndrome or toxic side effects of cardioactive drugs.<sup>2,3</sup> In a few rare cases, SCD can be caused by a direct blow to the chest – commotio cordis (CC).<sup>4</sup> These instances of mechanical-electrical arrhythmogenic failure are triggered by a blunt, non-penetrating, and often apparently innocuous unintentional blow to the chest, without any damage to the sternum, ribs or heart<sup>5</sup> and without any underlying cardiovascular disease.<sup>6</sup> There is usually a poor response to resuscitatory measures<sup>7</sup> with a mortality rate of over 80%.<sup>4</sup> Commotio cordis is thought to be responsible for 2 to 4 deaths every year in the United States, but underreporting and misclassification of deaths undoubtedly occur and the true number of deaths caused by relatively mild chest wall impacts is unknown.<sup>8</sup> Since being launched in 1996, the United States Commotio Cordis Registry (USCCR – Minneapolis, Minnesota) has recorded more than 224 cases.<sup>6,9</sup> The syndrome predominantly affects young males, who suffer trauma during physical activity. This article focuses on a

case of fatal commotio cordis in a woman following an accidental fall on the beach.

## 2. Case report

A 20-year-old girl, in good health and with no significant personal and familial previous medical history, was running on the beach with friends when she fell accidentally on the wet sand and sustained a non-penetrating chest wall impact. She immediately stood up unaided, before falling back to the sand. After 30 s, her friends found her unresponsive, with agonal respiration, cyanosis of the lips and a weakened pulse. She rapidly entered a state of cardiac and respiratory arrest. Her friends, and subsequently the paramedics, both performed emergency resuscitation at the scene. She was pronounced dead after 30 min of attempted resuscitation.

Autopsy showed an overweight and well-nourished young adult, 177 cm tall and weighing 88.6 kg. Postmortem hypostasis on the back was clearly visible. There were no significant injuries, except for a superficial, rectangular abrasion in the sternal region measuring 14 cm × 7 cm compatible with the effects of emergency resuscitation. The thoracic cage was entirely intact and the internal examination revealed nothing out of the ordinary. The sternum was intact and no fractures were found in the bilateral ribs. There was no evidence of internal bleeding. The heart was of normal size, weighing 313 g, with a width of 15 mm in the left ventricular wall and 4 mm in the right ventricular wall. The heart was without

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congenital anomalies or myocardial injuries, except for some petechiae on the posterior epicardial surface. Histological study of the heart included 4 sections of the sinus node, 4 sections of the atrioventricular node and 16 sections of the ventricles stained with H&E and Masson's Trichrome. The conduction system showed no abnormalities and we did not observe any alteration in the walls of the small vessels neither myocardial disarray. No haemorrhage was found in the sinoatrial node and no myocardial hyperplasia or atrophy in the myocardium was detected. The other internal organs showed signs of oedema, and a severe congestion in both lungs.

Postmortem toxicological analysis was negative for alcohol, drugs and common toxicants.

Molecular investigation eliminates an SCD secondary to an arrhythmogenic syndrome such as long QT or Brugada syndrome.

### 3. Discussion

Comotio cordis is a rare cause of fatal cardiac arrest, with only 224 reported cases since creation of the National Comotio Cordis Registry in Minneapolis 15 years ago,<sup>6</sup> according to Zheng N et al. (2013) who also report two cases of sudden death associated with comotio cordis between 1999 and 2008.<sup>5</sup>

Comotio cordis occurs in a wide variety of circumstances, mainly caused by accidental blows sustained during sporting activities. Baseball, softball, ice hockey, football and lacrosse are the most common sporting activities in which this syndrome occurs.<sup>10</sup> Non sport-related accidental contact with hands, feet or elbows,<sup>7</sup> as well as uses of less lethal weapons like flashballs<sup>11</sup> and a few criminal cases are reported in the literature, including an instance of comotio cordis in a 7-week-old child who had been already subject to abuse.<sup>12</sup> Young males are the group most commonly affected, primarily children and adolescents.<sup>6,13,14</sup> The mean age of victims is 14 years, with 78% <18 years of age. Young athletes may be particularly at risk because of their more pliable chest wall. The elasticity and compressibility of their chest wall facilitates the transmission of impact energy to the myocardium. In the case at hand, the victim does not fit this profile: she was an overweight 20-year-old adult and the sudden death occurred after an accidental fall from her own height without any external intervention. The mechanism of onset of comotio cordis is well known: the initial event was a precordial impact with a low-energy mechanical effect on the heart during a vulnerable period before the T-wave peak, corresponding to the ventricular repolarisation<sup>15,16</sup> which triggers ventricular fibrillation. According to Madias et al. (2007),<sup>17</sup> a blow falling during this period results in a rapid rise in left ventricular pressure with likely activation of ion channels via mechanical-electric coupling leading to premature ventricular depolarisation and ventricular fibrillation. The rate of successful resuscitation is low, and only 10% of the 70 patients reported in the American registry survived. 52 received cardiopulmonary resuscitation (CPR) within 3 min and after a CC only 2 of 70 victims went on to make a full recovery.<sup>18</sup> The same is true in the case under consideration here: the victim rapidly received CPR performed by friends and emergency medical personnel, but death was declared 30 min after the paramedics' arrival at the scene.

For comotio cordis to be diagnosed, there must be no damage to the sternum, the ribs or the heart and no underlying cardiovascular diseases.<sup>5</sup> In the current case the macroscopic evidence was consistent with comotio cordis and the autopsy no found significant injury to the cranial cavities or internal abdominal or thoracic haemorrhaging. Moreover, upon microscopic examination of the heart, including the conduction system and coronary arteries, it appeared to be normal except for scattered punctuate haemorrhages on the epicardium, frequently observed in cases of sudden death by cardiac arrhythmia. Toxicological analyses were negative for alcohol and cardiotoxic drugs such as cocaine. Hamilton et al. (2005) suggest that alcohol sensitises

the heart to the effects of catecholamines, and can thus increase the risk of arrhythmia.<sup>19</sup> Cocaine increases consumers' exposure to a great variety of cardiac arrhythmia, including sudden death,<sup>20,21</sup> but the presence of arrhythmogenic drugs may be considering as a factor contributing to arrhythmia and not as a specific risk factor.<sup>22</sup>

In many forensic cases, it is hard to make a clear diagnosis of comotio cordis, for two main reasons<sup>22</sup>: the difficulty of correctly identifying the cause and the manner of death, and the difficulty of making judicial authorities understand how a minor blow to the chest may result in the death of a young and healthy person. The first point requires a rigorous medico-legal approach, and a conscientious effort to obtain much information as possible (death scene report, emergency services report and witness statements). In this case, the witness statements were crucial in explaining the chest impact on the sand and the ensuing, rapid death.

#### Ethical approval

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#### Conflict of interest

None.

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